WATER FILTRATION BY THE BAY SCALLOP, PECTEN IRRADIANS, AS OBSERVED WITH THE USE OF RADIOACTIVE PLANKTON [1]

WALTER A. CHIPMAN AND JEAN G. HOPKINS

Shellfish Laboratory, U. S. Fish and Wildlife Service, Beaufort, North Carolina

Studies of the movement of sea water through the mantle cavity by lamellibranch molluscs and the efficiency of the gills in removing particulate matter from this flow are of considerable interest to biologists concerned with investigations of the feeding activities of these bivalves. Only through a more complete understanding of the factors controlling the rate of water propulsion, the retention of particles by the gills, and the ingestion of filtered material can we approach problems in the nutritional physiology of these animals.

The rate of water propulsion of a number of species of lamellibranchs has been reported by investigators using either direct measurement techniques or indirect methods based on the reduction of the number of particles in a suspension in which the animals have been placed. Considerable work has been done on the factors affecting the rate of pumping of oysters using direct measurements of the rate of flow following, in general, the experimental arrangement described by Galtsoff, Chipman, Hasler and Engle (1938). The important part of this technique is the use of an "apron" developed by Nelson (1936). In many lamellibranchs direct measurements cannot be made and indirect methods have been widely used. About the first of these measurements that may be considered as truly quantitative was that of Fox, Sverdrup and Cunningham (1937). Their experiments were based on the chemical determination of changes in the calcium content of suspensions of calcium carbonate in which *Mytilus californianus* were placed. The use of plankton in suspension with photoelectric determination of changes in concentration resulting from the activity of the animals was suggested by Jørgensen (1943). Colloidal graphite was used by him in later studies (1949a, 1949b, 1952, 1953) in measurement of conditions affecting the pumping rate of filter-feeding invertebrates and the relation of this rate to metabolic activity. Rao (1953) used these techniques to advantage in his studies on the rate of water filtration of *Mytilus californianus* from different latitudes.

With the availability of methods of labeling plankton cells with radioactive isotopes and the extremely accurate technique of measuring changes in cell numbers based on the detection of small amounts of radioactivity contained in such cells, it seemed advantageous to employ these methods in studies of the filtration rates of filter-feeding invertebrates. Consequently, we have used plankton containing radioactive phosphorus in studies of the rate of water propulsion of the bay scallop, *Pecten irradians* Lamarck, one of the more active species of lamellibranchs, which could lead

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to further work on the factors concerned with filtration rate and feeding in these and other related marine molluscs.

Materials and Methods

The scallops were collected from the vicinity of the Shellfish Laboratory of the U. S. Fish and Wildlife Service at Beaufort, North Carolina. They varied in size according to their age. They were all of the same year class, spawn of the fall of 1952, and consequently were rather uniform in size for any date of collecting. No very small scallops nor very large scallops were used. The smallest were those studied in June of 1953, and the largest those collected in October, 1953. Spawning of some scallops took place in the laboratory jars starting August 7 and was observed as late as early October. The biology of this species is well covered in a paper by Gutsell (1930).

Observations were made on single scallops immersed in suspensions of plankton cells in sea water. The volume of the suspension was usually 3 liters. With the small scallops a few observations were made in volumes of 1.5 liters, while the largest were tested in 6-liter volumes. The suspensions were well stirred by a stream of air bubbles. It was necessary to fasten the scallops to an L-shaped glass rod to prevent their swimming about. Since the scallop is very sensitive to the movement of an object in the near vicinity, the jars were well enclosed in a wrapping. When not under observation, the scallops were kept in running sea water.

The salinity of the sea water in the laboratory ranged from 31 to 36 parts per thousand, usually being about 34 parts per thousand. Heavy rains accompanying a hurricane in August reduced the salinity to a low of 14 parts per thousand, but no observations were made at the time of low salinity. The sea water used for preparation of the suspensions was aged sea water and plankton-free. It had a salinity of 35 parts per thousand. The scallops were not subjected to any significant change in salinity during the tests.

Observations were made at room temperature, which was held relatively constant throughout the summer and fall. The experimental suspensions ranged from 21.9° to 25.8° C. Variations during any one period of observation averaged 0.50° C., and only twice exceeded 1.0°.

Single species cultures of a diatom, *Nitzschia closterium* (56 microns in length), and a flagellate, a species of *Chlamydomonas* (7 microns in size), were made radioactive from the incorporation of radioactive phosphorus,[2] P^{32}, following the methods developed at our laboratory (Rice, 1953).

It is not difficult to culture many species of phytoplankton so that each cell is highly radioactive. These cells, when grown in enriched sea water containing virtually no phosphorus excepting the carrier-free radiophosphorus, will take up large amounts of the isotope. This isotope is a useful one emitting only β particles of rather high energy and very measurable. Since phosphorus is one of the major nutrients required, the P^{32} will be incorporated rapidly into organic compounds with little remaining in the exchangeable phosphorus of the cells. With rapidly dividing cells grown in this way, there is practically no radioactivity outside the cells in the sea-water medium.

[2] Obtained from the Oak Ridge National Laboratory on allocation from the U. S. Atomic Energy Commission.

The concentrated phytoplankton cultures, or portions of them, were added to the aged sea water to give the desired cell concentration. The number of cells present after dilution was calculated from measurements of aliquots of the concentrated culture using an improved Neubauer haemocytometer. Changes in the cell concentration of the suspension were followed by radioactivity measurements of aliquots removed at regular intervals. In some experiments samples were taken at various locations in the jar. No significant differences were noted, and the measurements made for each time interval were averaged. Control jars without scallops were sampled in order to measure the rate of settling of the suspensions. Although measurable, settling was so slight as to be negligible. Since the cell population after dilution could be calculated from exact microscope counting, and the radioactivity of the cells accurately measured, any changes in cell population could be detected even though extremely slight. It would be quite impossible to detect such slight changes occurring in short periods of time in dilute suspensions using electrophotometer measurements. In fact the original starting concentration was often lower than that which would give a measurable difference from ordinary sea water blanks using such equipment.

The radioactivity of 10-ml. aliquots of the plankton suspension was measured after the addition of nitric acid to disintegrate the cells and dilution to 25-ml. volumes. A dip type Geiger-Müller (G-M) counting tube was used immersed to a fixed depth in a 50-ml. centrifuge tube and connected to the conventional type scaler. Necessary correction for radioactive decay of the P^{32} was made.

It was originally thought that observations with the G-M tube immersed directly in the suspension would do. However, there was soon an accumulation of radioactive cells around the tube even though it was treated with the non-wetting agent, Desicote. Another objection was the limited time of measurement which might not provide enough counts to give the desired accuracy.

Dilution of the phytoplankton culture with sea water to give the experimental cell concentration was great and very little P^{32} was in the sea water of the suspension. Nearly all the radioactivity was within the cells. However, duplicate aliquots of the suspension were filtered through a freshly-prepared barium sulfate precipitate held on a No. 42 Whatman paper and the small amount of radioactivity of the filtrate averaged and subtracted as an additional background for each observed reading. The preparation of this very retentive filter was described by Rice (1953). Filtration at the end of the observations showed the radioactivity measured was due to the presence of cells.

Results

On being immersed in an experimental phytoplankton suspension, the scallops opened almost immediately and soon started to filter the water through their gills. This resulted in a lowering of the cell content of the suspension. A semi-logarithmic plot of the cell concentrations measured at frequent intervals throughout the period of observations was made to visualize these changes. Figure 1 shows examples of the rate of clearing of suspensions of *Chlamydomonas* and *Nitzschia* cells with different concentrations of cells at the start of the experiments. The rate of clearing varied, but followed the same pattern in nearly all of the tests.

There was a gradual increase in the rate of reduction for a time following the immersion of the scallop. Generally, this took place rather promptly, although in a

few instances the decrease in cell number was delayed slightly. This gradual increase in rate of reduction of phytoplankton cells at the start of the observations would be expected since the experiments were started with immersion in the suspension. It was, of course, necessary for the scallop to adjust itself to the new conditions and resume its filtering activities. There was no delay from failure to open as

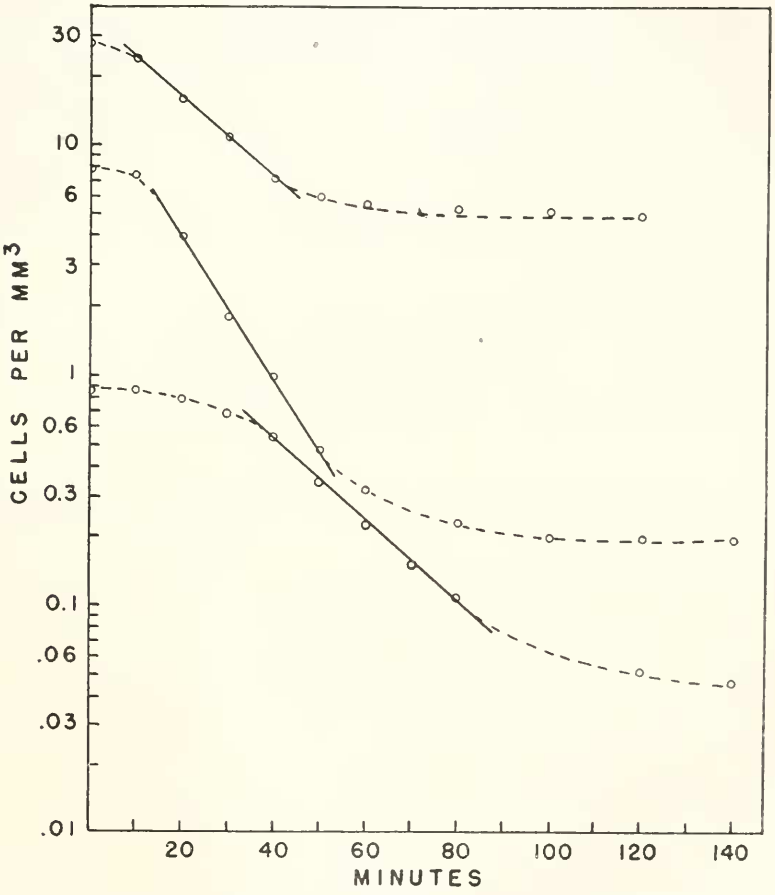

FIGURE 1. Changes in concentration of phytoplankton cells in suspensions with time after immersion of scallops. Upper curve was with use of *Chlamydomonas* cells, lower two with *Nitzschia*. The solid lines represent the calculated regression lines.

might occur in tests using other lamellibranchs. Normally scallops do not remain closed for any long period.

After the initial changes in the rate of particle reduction, a nearly constant percentage decrease of the suspended phytoplankton took place. The regression line for the logarithms of the cell concentrations observed during this decrease was calculated by the method of least squares and drawn for each of the experiments. The solid straight lines of the graphs in Figure 1 represent the calculated regression lines.

The observed points fall very close to these lines. In some instances it was possible to draw a straight line connecting the observed points.

If one assumes that the conditions of the experimental arrangement were satisfactory, the straight line decrease in the logarithm of the cell concentrations with time fits the mathematical equation for a constant rate of water filtration with complete removal of the suspended phytoplankton from the water filtered by the scallop. During this time of complete removal, the observed rate of decrease in cell concentration may represent the rate of water filtration of the scallop. Changes in the rate of clearing of the suspension can be interpreted as resulting from changes in the amount of water filtered. In our experiments it seems likely that the rate of clearing of the suspension was representative of the rate of water propulsion of the scallops during this period of the observations.

As the observations were continued, the decrease in phytoplankton became less and less. This resulted in a flattening of the curves. Although not shown in Figure 1, the number of cells in suspension gradually increased in instances where the observations were prolonged.

There are a number of factors concerned with determining the rate of reduction of particles in suspensions in which the scallops were immersed for observation of their filtering activities. Different ones of these may affect the rate at different times, or more than one factor may be acting at one time. The flattening of the curves of our observations, therefore, may not have resulted from a change in the rate of water filtration.

The decrease in rate of removal was apparently related to time in the suspension. It was not related to cell concentration. Series of observations were made starting the scallops in concentrations of either *Nitzschia* or *Chlamydomonas* at which there was a previous leveling-off in the rate of removal. In each series there was rapid removal followed by a less rapid rate, regardless of the starting cell population. This occurred even in starting concentrations of *Nitzschia* cells of 0.85 per $mm.^3$ and in which a leveling-off of the curve took place at 0.04 cell per $mm.^3$.

Incomplete mixing of the filtered water with the unfiltered suspension would result in a decrease in the observed rate of phytoplankton removal that would get less and less as the observations were continued. Changes in the amount of stirring of the suspension in the jar were tried. Even rather violent stirring did not alter the shape of the curves in our experiments. A number of aliquots taken from various locations in the suspension did not appear to differ significantly from each other. Although it is realized that it is virtually impossible to get the mixing required to fully meet the requirement of the mathematical expression giving a straight line decrease, we believe that recirculation of filtered water through the scallop before mixing was not wholly responsible for the flattening of the curves we observed.

The decrease in the rate of removal reflected in the flattening of the curves could be interpreted as a change in the rate of water propulsion of the scallop. However, such a change was not apparent. The scallops were seen to be creating a considerable current of water even when there was no appreciable decrease in suspended plankton. This was also true when the cell concentration of the suspensions increased from a return of phytoplankton cells after earlier removal. It seems not unlikely that the change in the rate of clearing of the suspension was a result of a changed efficiency in the filtering by the scallop, together with a return of cells previously entrapped in the mucus of the gills.

TABLE I

Water filtration rates of scallops

Range in shell length (mm.)	Weight of meats (gm.)	Starting concentration (cells/mm.[3])	Liters/hour filtered		Rate per scallop (l./hr.)	Rate per gram (l./hr.)
			Nitzschia suspensions	Chlamydomonas suspensions		
38–44		20		2.3		
		21	4.0			
		23	1.0			
		23		1.9		
		32		3.5		
		32	4.1			
		44	3.4			
		50		5.9		
		56		5.5		
		57		1.0		
Average	3.3		3.13	3.35	3.26	0.99
47–48		23	13.8			
		34	7.8			
		38		6.5		
		44		9.9		
		78	8.0			
		85	3.3			
Average	8.8		8.22	8.20	8.21	0.93
54–56		2.2	14.7			
		4.7	19.3			
		6.4		10.5		
		8.6		13.3		
		11	5.6			
		21	6.7			
		27		3.5		
		31		8.6		
		33		9.0		
		57	8.5			
Average	12.7		10.96	8.98	9.97	0.79
64–65		0.85	9.8			
		1.0	21.6			
		7.9	25.4			
		22	14.0			
		22	16.3			
		22	13.6			
		22	21.5			
		34		6.8		
		38	5.5			
		52	16.6			
		59	10.8			
Average	20.6		15.51		14.72	0.71

If one assumes that the scallop was filtering the suspension efficiently with complete removal of the suspended particles, it is possible to calculate the rate of water propulsion by the application of the formula given by Jørgensen (1943). This is

$$conc_t = conc_0 \cdot e^{-\frac{m}{M} \cdot t}, \text{ or } m = \frac{(\log conc_0 - \log conc_t) \cdot M}{\log e \cdot t}$$

in which M is the volume of suspension in liters, m is the quantity of water moved in liters per hour, while $conc_0$ and $conc_t$ are the cell concentrations at the initial time and after t hours of time. Undoubtedly the rates obtained are not absolute. They can only represent an approximation since the original assumption made is not likely to be entirely correct. Escape of the plankton through the gills, if occurring as a fixed percentage of the concentration in the suspension, would not change the nature of the curve but would alter the slope. The measured pumping rate may actually be lower than the true rate.

In our observations we can well assume that the changes in cell concentration in the suspensions represent efficient filtration with complete removal of the suspended cells by the gills excepting for the latter part of the observation times when flattening of the curves took place. We have therefore calculated the rate of water propulsion for the scallops for that time after adjustment to the immersion during which a semi-logarithmic decrease in suspended phytoplankton cells occurred. The rates for observations of different sized scallops immersed in suspensions of *Nitzschia* or *Chlamydomonas* at the various concentrations tested are shown in Table I.

Individual scallops in observations made at different times differed in their rate of filtration, but under like conditions of test the rates were reasonably uniform. The average rates were the same for experiments using either species of phytoplankton for the suspended material. They did not appear to be related to concentration. As the scallops increased in size, their rate of water filtration increased. In June and early July the small scallops averaged about 3 liters per hour. Later during the summer they filtered increasing amounts, and by fall were pumping an average of nearly 15 liters per hour. The maximum rate observed was 25.4 liters per hour for a scallop measuring 65 mm. in length. We did not determine the rate of filtration of the scallops in late fall or early winter when the average size of this year class was somewhat greater.

Although the number of observations was small, the average rate of water filtration per gram of tissue was greater for the smaller scallops than it was for the larger. It is not known what effect the development of the gonads in the late summer may have had on the rate of filtration.

Discussion

The use of radioactive plankton cells for determination of changes in the concentration of cells in suspensions in which a filter-feeding animal is placed is valuable for studies of the filtering activities of these animals. Since the cells can be made very radioactive, it is possible to use very dilute suspensions. It eliminates the need for growing large quantities of plankton in culture for such experiments. The suspensions can be made more comparable to normal sea-water environments. Even in a large volume of suspension in relation to the animal under observation, repeated

frequent sampling with the withdrawal of small aliquots is possible. The accuracy of determining radioactivity in extremely minute amounts allows very accurate estimation of cell numbers. No attempts were made in the present study to explore the limits of determination of changes in cell concentrations, nor how few cells in suspension could be measured. However, the radioactivity of the plankton cells used could have been increased considerably, and larger aliquots could have been taken. In all the experiments the aliquots were diluted for radioactive counting and a counter with a rather thick wall (30 mg./cm.^{2}) was used.

The rates of water filtration were measured in cell concentrations well below those that were found by Loosanoff and Engle (1947) to interfere with the pumping activities of oysters. The concentrations used were within those that the scallop might encounter in nature. A short review of the literature on the estimation of phytoplankton abundance in the sea is given by Bainbridge (1953). Galtsoff (1949) presents a discussion of blooming of plankton in the sea. He reports the number of *Gymnodinium* in the surface water in a red tide off Florida as reaching a concentration of 56 cells per mm.^{3}. Cole (1939) measured the phytoplankton content of the sea water pumped into his experimental oyster tanks, and Gaarder and Spärck (1932), Alvik (1934), and Gaarder (1938) report observations for Norwegian oyster pools and fjords. Their values range from 4 to 24 cells per mm.^{3}. Recently, in Great Pond, Massachusetts, a tidal estuary, Hulburt (personal communication) observed a range of phytoplankton from 1.8 to 24 cells per mm.^{3} in carefully counted samples through different seasons. For more open waters, Riley (1941) states that the range he found on Georges Bank from September, 1939 to June, 1940 was from 0.15 to 85 phytoplankton cells per mm.^{3}. Except for most unusual situations, diatoms generally are not as abundant as flagellates and smaller nannoplankton. The importance of nannoplankton in the food-chain cycles of the sea has now become recognized. It is likely that the normal population of diatoms in the sea is about 0.5 cell per mm.^{3} (Hardy and Gunther, 1935). It can be seen that the cell concentrations used in our experiments may not be excessively high, with the possible exception of some in which the diatom *Nitzschia* was employed.

Although the indirect method of measuring the rate of water filtration of lamellibranch molluscs has been used in a number of studies, only in two papers has detailed information as to the changes in the rate of particle reduction during the time of observation been given. Fox, Sverdrup and Cunningham (1937) show data indicating a semi-logarithmic decrease in suspended calcium carbonate with time of observation in experiments using the California mussel. Such a decrease indicates complete removal of the suspended material from the water filtered by the mussels and a rate of filtration relatively constant for the time of measurement. They did observe, however, in certain preliminary experiments a gradual decrease in the rate of reduction with time. This did not take place in later experiments when adequate stirring was provided to minimize the effect of recirculation of filtered water through the mussels.

Jørgensen (1949a) compared the rate of water filtration of the mussel, *Mytilus edulis,* when immersed in suspensions prepared with colloidal graphite, the diatom *Nitzschia,* and three species of flagellates. Changes in the concentration of the suspensions were determined photometrically. The rates of filtration, calculated on the reduction of suspended material, varied with the type of particle used and often

changed during the period of observation. In his experiments using graphite particles, there was a gradual decrease in the rate of clearing; the rate at the beginning of the experiments was greater than at the end. In a few observations in which the phytoplankton constituted the suspended material, there was also a decrease in the rate of clearing of the suspensions. For most experiments using plankton cells, however, he found the rates constant or increasing during the tests. In many instances he reports the rate at the end as being greater than at the start.

In our observations on the rate of clearing of suspended phytoplankton cells by the scallop we found, as did Jørgensen for *Mytilus*, an increasing rate of clearing after the start of observations. This was followed by a time during which the rate was relatively constant. However, in our experiments, as we continued the observations further there was a lessening of the rate of removal of phytoplankton cells similar to the change observed by Jørgensen when suspended graphite particles were used. Later, if the observations were still further continued, there was an increase in the number of cells in suspension.

The pelecypods are able to change the efficiency of their gills as a filtering organ. They form a mucous coat over the gill surface which results in efficient particle retention. The importance of the mucous coating in the feeding activity of lamellibranchs has been stressed by MacGinitie (1941). There is also a possible change in pore size by regulation of the ostea of the gills. Galtsoff (1928) observed that a great number of bacteria added to the sea water were not retained by the gills of the oyster. Similar findings of variations in the retention of bacteria by oysters were reported in more recent work using millipore filters (Galtsoff and Arcisz, 1953). Loosanoff and Engle (1947) observed great variations in the numbers of *Chlorella*, *Nitzschia*, and *Euglena* removed by the gills of oysters at different times. Jørgensen (1949a) interprets the changes he observed in the clearing of graphite suspensions by *Mytilus* as probably due to the change in efficiency of the gill with a stopping of the secretion of mucus if the particles in suspension were unsuitable for food or the animal disturbed. The efficient removal of the phytoplankton cells was explained in the light of an entrapment in the mucous sheet. Jørgensen and Goldberg (1953) present data showing that the graphite particles used in their experiments were retained almost completely in the filtering organs of the lamellibranchs and the ascidians tested.

In our experiments with the scallop, it seems that the changes in the rate of clearing of the suspensions of phytoplankton cells probably were directly related to the efficiency of the gills. There was an apparent complete removal of the cells from the filtered water after the scallops had become adjusted to the conditions of the experiment. It seems likely that there was formation of a mucous coat which allowed complete retention of the cells in the gills. As the experiments progressed, there was a return from the mucus to the suspension of cells previously removed. This return took place in increasing amount. There may also have been a lessening in the efficiency of the gills in removing suspended cells. It would be unwise to ignore entirely the possibility that the conditions of experimental arrangement had no influence on the observed changes in the rate of clearing of the suspensions. It is almost impossible to have the exact mixing of the filtered water with the unfiltered suspension required to present the scallop with the properly diluted suspension each moment.

The filtration rate may not indicate a true feeding rate, for removal of the cells from the suspension may not result in ingestion by the scallop. Considerable work remains to be done on the role of the mucous coat in filtration and feeding activities. The factors concerned with changes in the secretion of mucus and those governing sorting for ingestion of filtered material need further investigating.

The complete removal of the suspended plankton cells from the water filtered by the scallop allows the use of measurements of the rate of particle reduction to serve as a means of calculating the rate of water propulsion. This indirect method is valuable when methods of direct measurement of the flow are not feasible.

There were no apparent differences in the rate of water filtration of the scallops when immersed in suspensions of phytoplankton cells of different concentrations. Loosanoff and Engle (1947) found that the water filtration of the oyster was reduced when exposed to heavy suspensions of micro-organisms. They observed no effects, however, when the concentrations were light and more comparable to those which may be expected to occur in natural marine waters. Although the threshold concentration for effect varied with the size of the species employed, the values found were high. They reported that oysters were able to reduce the population of plankton to concentrations below this threshold rather rapidly in small containers and then were able to clear the suspension normally. It is conceivable that the concentrations used in our experiments exceeded the effective concentration threshold that would interfere with the rate of water filtration of the scallops and the small volume of the suspensions used enabled the scallops to reduce the cell numbers rapidly to a point below this threshold. If such were the case, we would have failed to observe the effects of concentrations above this threshold on the rate of water filtration. It would be possible to increase the volume of the experimental suspension greatly and provide adequate mixing. The scallops then would reduce the population of plankton cells more slowly and be exposed to high concentrations for greater times. The use of radioactive plankton would still allow the measurement of slight changes in cell numbers. It would be interesting to observe if thresholds of cell concentrations affecting the filtration rate existed that were within those concentrations that the scallop might encounter in nature. In low densities the rates were not markedly increased or decreased over those in higher concentrations. This is in agreement with Jørgensen's observation (Jørgensen, 1952) that filtration rates were not influenced by low concentrations of available food in lamellibranchs and ascidians.

In our observations the scallops were found to have a rather high rate of water propulsion. This rate was greater for the larger scallops than for the smaller. Although the large scallops pumped greater quantities of water through the gills than did the small ones, the average pumping rate per gram of tissue in the larger was somewhat less. Our observations were based on a single year class followed as they grew to an age of 12 to 14 months. During this time there was, of course, development of ripe gametes, which may influence the rate as measured for the larger scallops, causing it to be somewhat high. Similar relationships of rate of pumping to size were reported for mussels by Jørgensen (1943, 1949a), Fox, Sverdrup and Cunningham (1937), Willemsen (1952), and Rao (1953).

If we consider the data available, it appears that the adult oyster (*Crassostrea virginica*) of about 4 or 5 years of age at summer temperatures probably has a water propulsion rate of about 12 to 14 liters per hour (Galtsoff, Chipman, Engle and

Calderwood, 1947; Loosanoff and Nomejko, 1946; and Jørgensen, 1952). Although actual data are not available, the oysters used probably weighed somewhat more than 12 to 14 grams. This would mean that the oyster has a rate of water propulsion a little less than one liter per hour per gram of body weight. This is about the rate observed by us for the bay scallop. For the large mussel, *Mytilus californianus*, Rao (1953) shows data indicating that at 20° C. the animals from 30 to 70 grams had a pumping rate of 5 to 6 liters per hour, and a rate per gram of only 0.1 and 0.2 liter per hour. Evidently this animal has a much lower rate of water propulsion than either the bay scallop or oyster. For *Mytilus edulis*, the rates per animal for small individuals at 22° were about 0.16 liter per hour and for larger from 0.3 to 0.4 liter per hour (Jørgensen, 1949a). For large individuals (70 to 80 mm. in length), at temperatures from 11.8 to 14.7° C. an average of 1.8 liters per hour was found by Willemsen (1952). It seems likely that *Mytilus edulis* may have a rate similar to that of *Mytilus californianus*. The cockle, *Cardium edule*, was found by Willemsen (1952) to have a rate of about 0.5 liter per hour for individuals of 30 to 40 mm. in length at temperatures from 17.3 to 19.5° C. This would indicate that sea mussels and cockles have a rate of water propulsion per gram much less than either the bay scallop or oyster.

Jørgensen (1952) has related the filtration rates of several filter-feeding invertebrates to their oxygen consumption. According to his findings there is a quite uniform ratio between the two in all such forms. In view of the fact that the bay scallop has a rapid rate of growth and is a very active animal, it is not surprising that the rate of water filtration is rather high. The oxygen consumption has not been determined, but it is likely to be also high, and may have the same relation to filtration rate that Jørgensen found for related animals.

Summary

1. The water filtration by the bay scallop, *Pecten irradians*, was studied by following the clearing of suspensions of plankton cells that had been made radioactive. The use of radioactivity measurement techniques for such studies of the rate of water propulsion of filter-feeding invertebrates by the indirect method allows detection of slight changes in cell numbers in dilute suspensions and is advantageous for investigation of the feeding activities of lamellibranch molluscs.

2. The scallops were observed to filter the water passed through their gills very efficiently with apparently complete retention of *Chlamydomonas* and *Nitzschia* cells after adjustment to the immersion in the suspensions. The rapid rate of decrease of suspended plankton was not continued, however, for there was evidence of a decrease in the efficiency of the gills and increasing return to the suspension of phytoplankton cells previously removed.

3. The bay scallop has a relatively high rate of water propulsion, probably correlated with its rapid rate of growth and active mode of life. The average rate for small scallops, 38–44 mm. in length, was 3.26 liters per hour. The largest scallops, about 12 to 14 months of age and measuring 64–65 mm. in length, averaged 14.72 liters per hour. The maximum rate observed was 25.4 liters per hour. The smaller scallops had a rate of about one liter per hour per gram of tissue, whereas the older scallops pumped an average of about 0.7 liter per hour per gram.

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